

Improved Performance of Ultra-Lightweight Cement Compositions

DOE Project

DE-FC26-00NT40-919

Conducted By Cementing
Solutions Inc.

Problem

- Lightweight Cements Needed for Critical Applications
- Conventional Lightweight Limited
 - Density – 11.5 ppg
 - Properties – Strengths
- Foam Cements
 - Difficult to apply/Evaluate

Potential Solution

- Add solid to the slurry
 - Low specific gravity – 0.32 to 0.46
 - High pressure resistance – 6,000 psi
 - Mechanical Bonding with cement
 - Easy to design, mix and pump

Light in Weight but High in Strength



Assemble Steering Committee

- Operators
 - ExxonMobil, Shell
- Service Companies
 - BJ, HES, Schlumberger
- Supplier of ULHS – 3M
- Cement Supplier - TXI
- Laboratory Equipment – Chandler Eng.

Objectives of Project

- Develop cementing systems using ULHS
 - Deep water applications
 - Other light weight applications
- Test physical performance
- Compare to conventional systems
 - Foamed and non-Foamed

Focus of Project

- Three Application Scenarios
 - Deep Water
 - Surface
 - Intermediate
- Comprehensive data set from Service Companies (over 500 data points)

Exposure to Stress

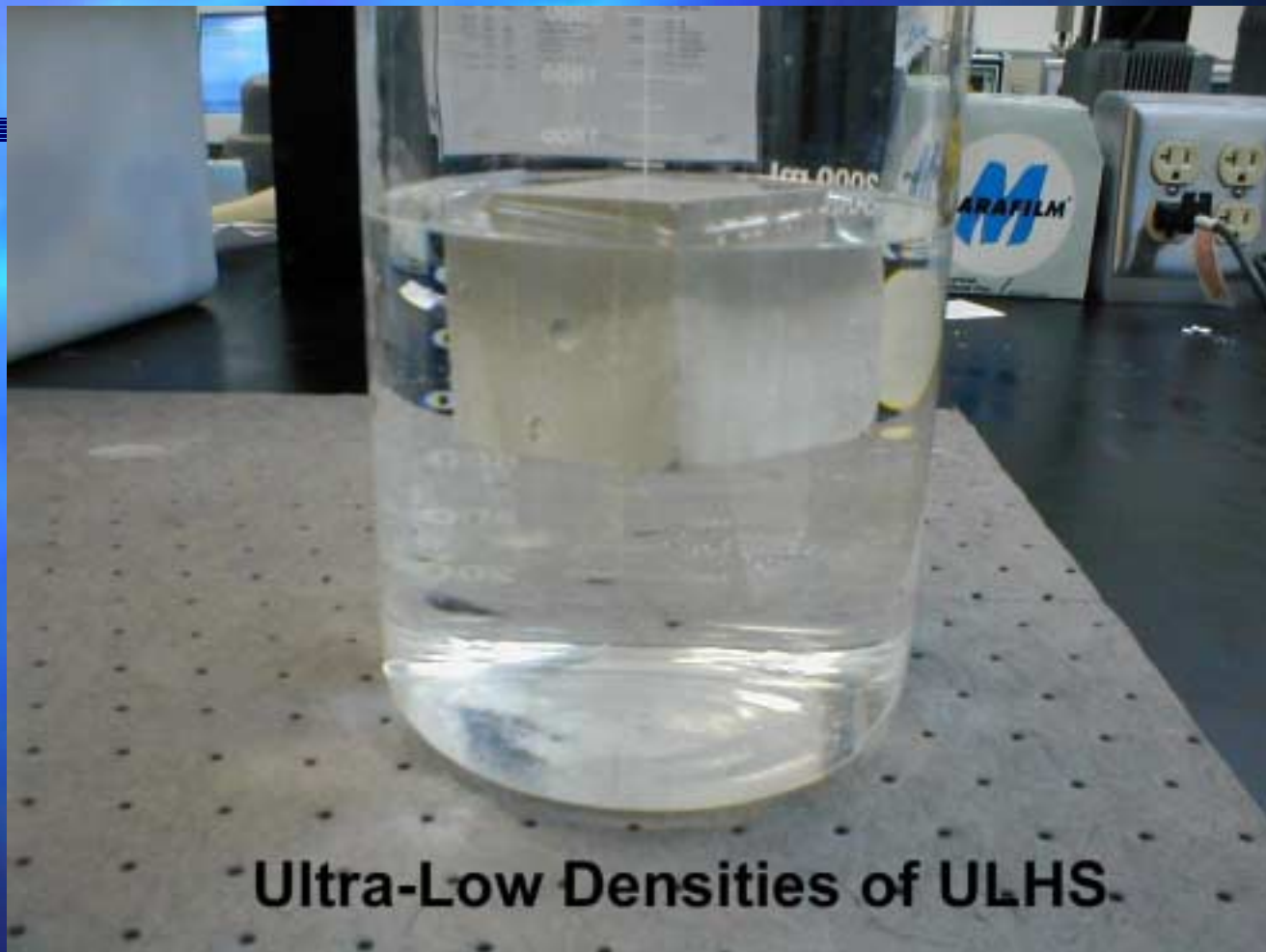
- Stress Cycling can deteriorate Cement Bond to pipe and ultimate seal
- Project testing:
 - Cycling Temperature change of 135 F
 - Differential Pressure Stress of 5000 psi

Lightweight Slurry Designs

- Conventional Extended Slurries
- Foam Cements
- Ultra-Light Hollow Spheres
 - Beads with crush strength of 3000 to 10,000 psi

Design of ULHS Cements

- ULHS slurries can be easily designed to densities as low as 8.0 ppg
- Conventional Tests and Properties Easily obtained in applications:
 - 45 F to 170 F

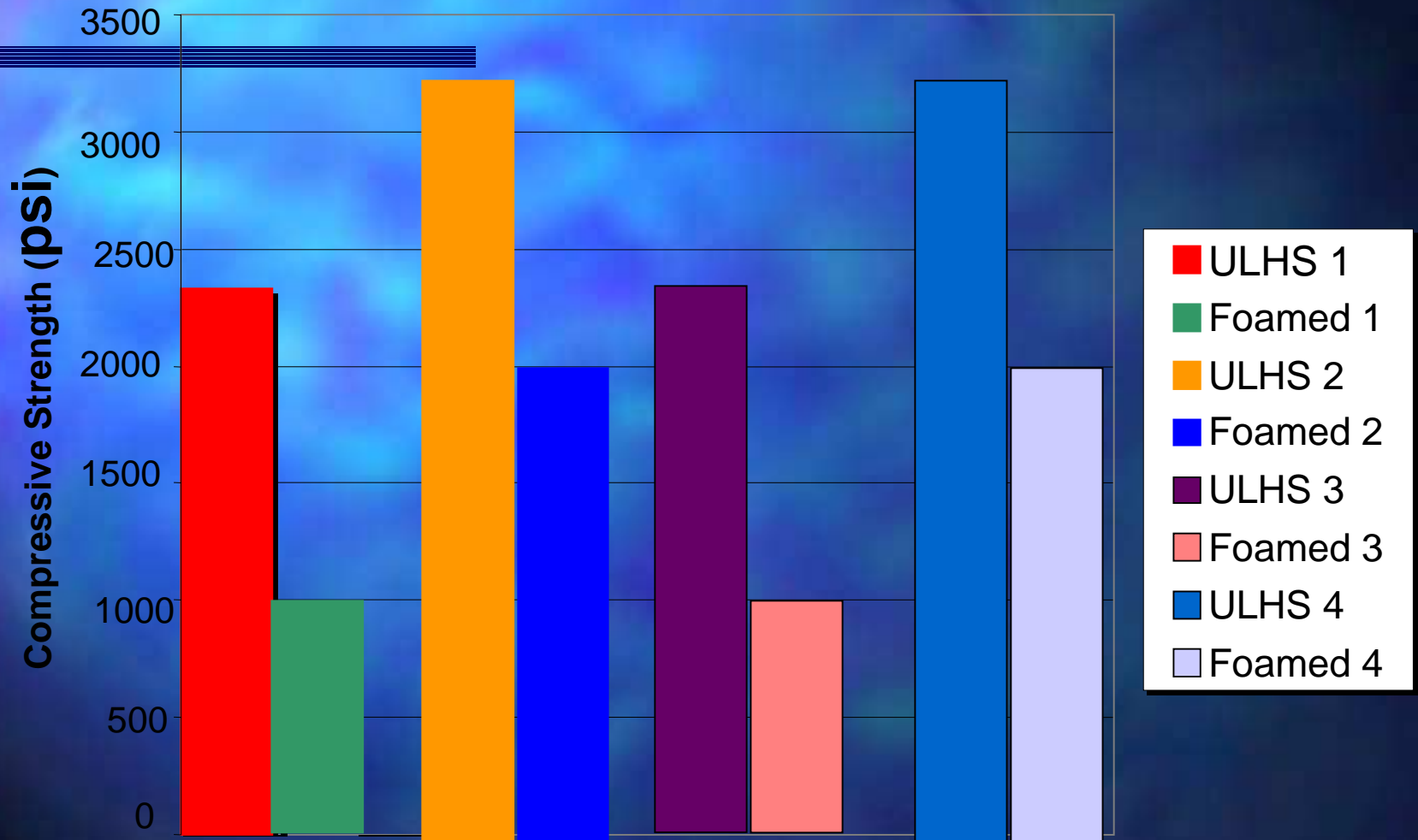


Ultra-Low Densities of ULHS

Mechanical Properties

- ULHS slurries Exhibit Higher Effective Compressive Strengths (tri-axial loading):
 - Foam Cements
 - Conventional Light Weight Cements
- Tensile Strengths
 - Higher than conventional cements
 - Similar to Foam Cements

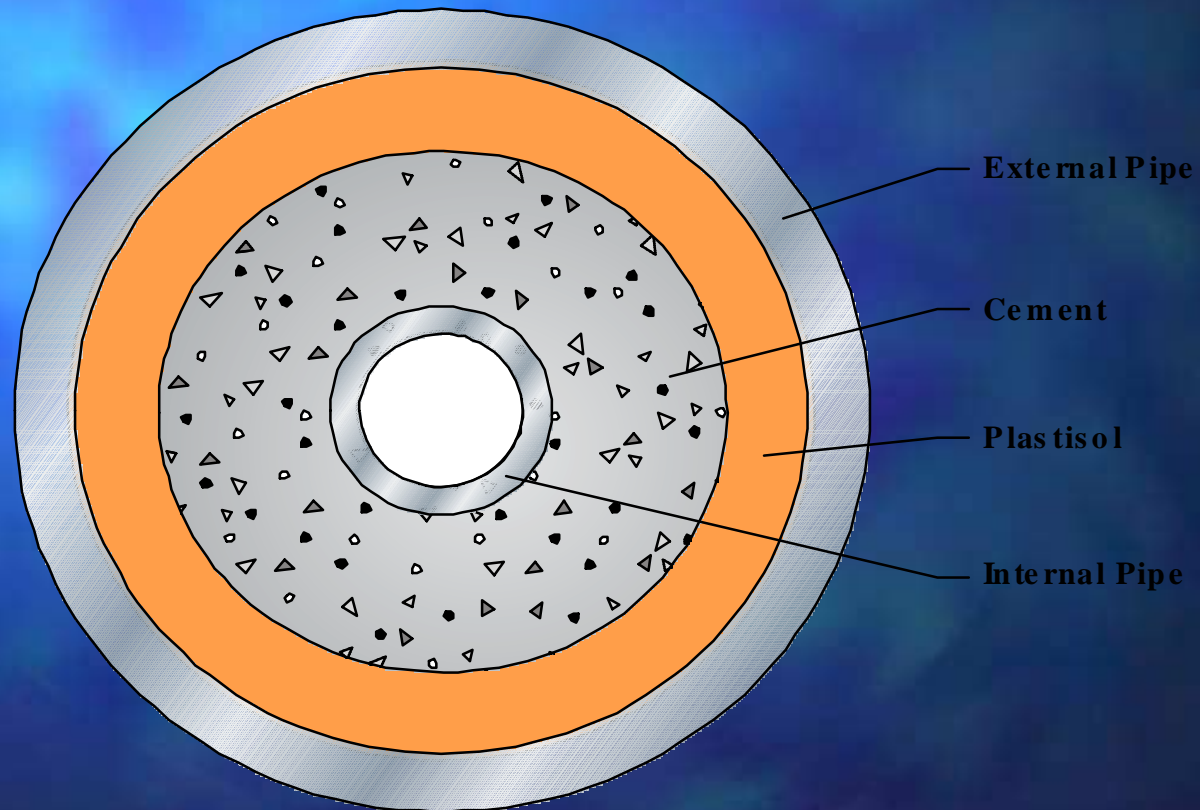
Foam VS ULHS Compressive Strength Testing 10.0ppg/ 11.5ppg Slurry



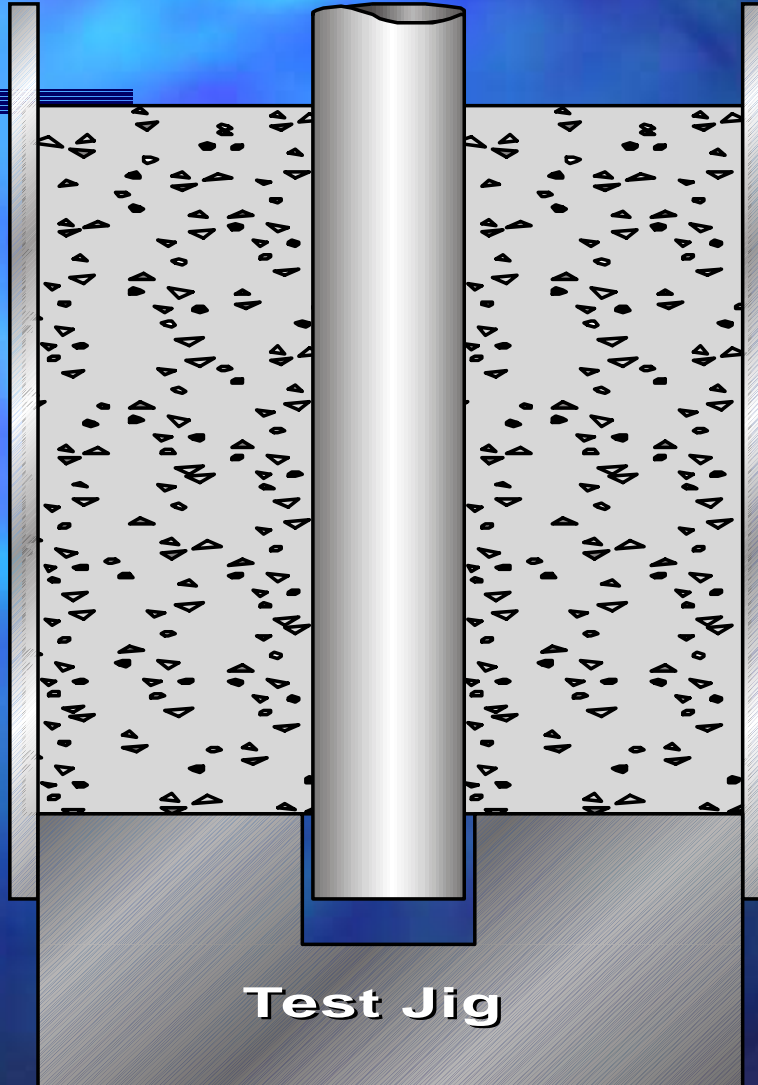
Shear Bonding of Light Weight Cements

- Excellent Bonding simulating:
 - hard formations - pipe
 - soft formations – special material
- Bonding Good after thermal cycling

Cross-Section of Pipe-in-Soft Configuration for Shear Bond Tests

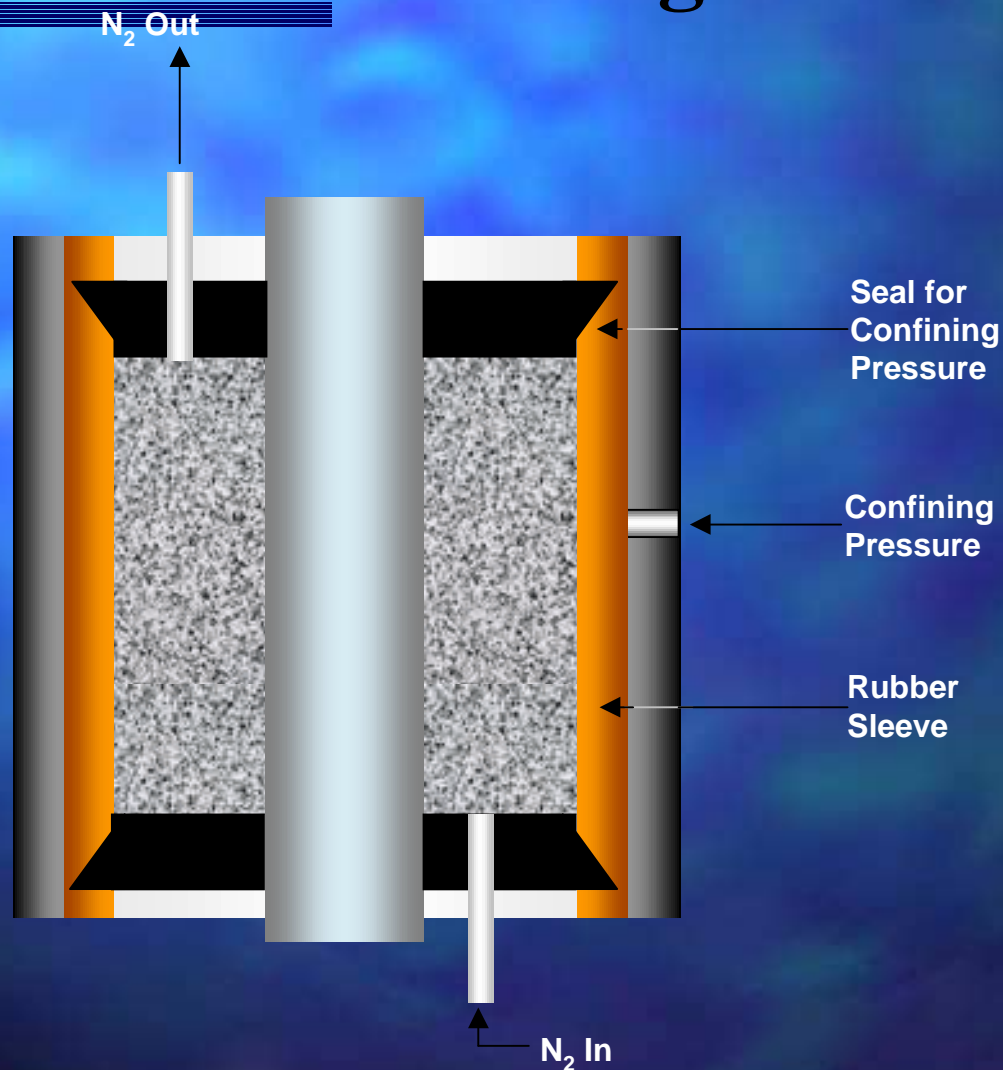


Force Applied Here



Test Jig

Cross section of annular seal model for pipe-in-soft configuration



Permeability of Set Cements

- ULHS cement Slurries down to 10 ppg
 - Low Permeability to water and gas
 - Less than Foam Cements and conventional cements

Field Mixing and Pumping

- Field Job Performed in South Texas
 - Easily Blended
 - Mixing and pumped with no Problems
- Field Job to be Performed in Rocky Mountains May 2002

Field Job #1

- Conoco - South Texas
- Conventional Light Weight Cements
- Add on ULHS slurry for Test
- Evaluation of Application in Deep Water
 - Mixing
 - Pumping
 - Logging Evaluation

Cement Job #1

November 2, 2001

- Zapata County, Texas
- TD: 9,024 ft
- BHCT: 153°F
- BHST: 218°F
- Hole size: 8 $\frac{3}{4}$ in.
- Intermediate casing: 7 in.
- ULHS slurry was first lead slurry (9.5 ppg)
- Designed for 1,000 ft of fill (depth: 7,520 to 6,524 ft)

Cement Job #1

- Mixing and Pumping
 - No Problems
- Logging
 - CBL not adequate to provide interpretation

Cement Job #2

- DOE/RMOTC – Wyoming
- Foam Cement used previous wells
- Critical Issues
 - Loss of Circulation
 - High Strength
 - Good Zone Isolation

Cement Job #2

July 19, 2002

- Natrona County, Wyoming
- TD – 5,765'
- 7" casing in 8 3/4" hole
- Lead Cement
 - 10 ppg ULHS with TXI Lightweight
- Tail Cement
 - 13.5 TXI Lightweight

Cement Job #2

- 100 bbls of ULHS slurry mixed and pumped (6k beads)
 - No breakage with one hour conditioning
- Ultrasonic and Sonic Evaluation Tools
 - Awaiting Logs
- RMOTC and HES very impressed with performance

Proposed Application

- Coal Seam Wells, Wyoming
- Formation damage with conventional cements (11.0 to 12.5 ppg)
- Proposed ULHS slurry
 - (9.5 ppg)
 - Requirements
 - 1000/1500 psi Compressive Strength 24/48 hours (80 F)
 - Good Perforating Qualities